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SEDIMENT QUALITY ON THE TORONTO WATERFRONT

May, 1974



Ontario

Ministry
of the
Environment

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Minister

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SEDIMENT QUALITY
on the
TORONTO WATERFRONT

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INTRODUCTION

Since 1970 the Water Quality Branch of the Ministry of the Environment has examined the water quality implications of marine construction projects. Impetus for the program was provided by public complaints about impaired water quality at dredging, landfilling and miscellaneous other water related construction activities. Further, in 1969, the report to the International Joint Commission stated that "the disposal of dredged material containing objectionable quantities of pollutants should be undertaken in such a manner that the materials will not damage the quality of waters and wildlife feeding areas in lakes Erie and Ontario."

In 1972, construction activities along the Toronto waterfront took a major upswing with the initiation of an ambitious landfilling program by the Metro Toronto and Region Conservation Authority; commencement of the first phases of the Toronto Harbour Commission's main harbour channel dredging, and dredging of the Western Gap by the Department of Public Works. The Toronto Harbour Commission also continued to do maintenance dredging in the Keating Channel and various slips and placed those spoils at the tip of the East Headland.

To evaluate the impact of these projects, information was needed on the nature of the sediments to be affected - in particular, the level of contaminants (if any) in those sediments. Literature available was unable to supply data on the chemical quality of the sediment, although information on the physical properties was found in papers by Fricbergs, Lewis and Sly, and Coakley.

The MTRCA intended to establish new recreational land along the waterfront using the methods developed by the Toronto Harbour Commission at the East Headland, namely, dumping common excavation material and rubble in patterns that would form stable beaches. Two sites were underway in 1972, one at the mouth of Mimico Creek and another at the foot of Brimley Road on the Scarborough Bluffs. A site was scheduled for commencement at Ashbridge's Bay in the immediate future and five other potential future sites were identified between Etobicoke Creek and Highland Creek.

The Canada Department of Public Works planned to dredge the Western Gap, the main shipping entrance to Toronto Harbour, to remove an estimated 50,000 cubic yards of sand and silt that had drifted into the channel.

The Toronto Harbour Commission had proposed dredging approximately 8 million cubic yards of material from the Outer Harbour area under a program of expanding and relocating port facilities to the Outer Harbour. The dredged material was to be disposed on the inner side of the East Headland in a configuration creating some 188 acres of land and sheltered lagoons designated as an aquatic park. To determine the feasibility of constructing land forms in water up to 30 feet deep with hydraulically dredged sand, the Toronto Harbour Commission first conducted two pilot dredging studies in the

outer harbour, one at the Water Rats Sailing Club and the other at the headland disposal site.

The Water Quality Branch examined the sediment quality at the specific construction sites and generally across the waterfront from Mimico to Ashbridge's Bay. Additional studies on various projects included scuba diver investigations before, during, and after construction; post-construction sediment quality sampling; and aerial photography to assess turbidity effects.

1. SUMMARY AND RECOMMENDATIONS

1.1 SUMMARY

The distribution of sediment types along the Toronto Waterfront has been significantly altered by recent construction activities. As the shoreline configuration is modified to create embayments, silts and clays accumulate over the original bottom sediments. The major sources of those silts and clays are the truck dumping operations by which the shoreline is being modified, sediment load carried by streams, and shoreline erosion. These recent mud deposits contain organics, nutrients, oil and grease and heavy metals in greater concentration than the original lake sediments. Further studies are underway to determine the sources of contaminants and assess their impact on water uses. Efforts are also being made to quantify the various sediment inputs to the lake and their relative contributions to turbidity in the nearshore zone. The MOE will extend and update their sediment sampling to obtain a data bank against which construction proposals and waste loadings can be evaluated.

1.2 RECOMMENDATIONS

- (i) Prior to initiating any further modifications to the shoreline or nearshore zone, a careful environmental impact assessment should be conducted by the originating agency.
- (ii) Landfills should be constructed such that they do not impair water quality or existing and proposed water uses. Specifically, placement of earth fill, rock and rubble must be co-ordinated having regard for ultimate shoreline configuration, material type and wave climate. Loose fine grained size material should only be dumped at the water's edge during calm conditions in zones protected from erosion by "hard points" built of rock, rubble and hard clay. Filling should be concentrated in one area at a time to ensure advancement of the fill with minimal water contact.
- (iii) Better disposal procedures for contaminated dredged spoils from the Keating Channel and harbour slips should be initiated to ensure containment of contaminants.
- (iv) Direct discharges of untreated or inadequately treated wastes via combined sewers should be discontinued by the earliest possible date. Studies of the effluent quality of storm sewers near recreational development should be conducted to determine their influence on proposed water uses.
- (v) Studies should be initiated to determine the extent and diversity of the benthic community along the waterfront, particularly in the areas that have been covered with contaminated mud deposits.
- (vi) Landfill projects should be designed and constructed to fulfill specific uses having regard to the water quality and sediment type requirements to satisfy those uses. Construction should be completed in the shortest practicable time to minimize the adverse effects associated with construction operations. Fills should be designed to minimize maintenance requirements, particularly maintenance dredging of contaminated sediments.

2. WATERFRONT DESCRIPTION

2.1 PHYSIOGRAPHY

The area examined encompassed the Lake Ontario nearshore zone from Ashbridge's Bay in the east to Mimico Creek in the west, but did not include Toronto Inner Harbour.

Ashbridge's Bay, now a small embayment at the westerly end of the Eastern Beaches, was once the site of a gap in the long sand spit which formed the Toronto Islands. The bay behind the gap has, since the turn of the century, been filled to create industrial land. Where the Don River used to flow into the lake, there are now only sewer outlets.

Immediately west of Ashbridge's Bay, the main east headland (18.2 million cubic yards of common earth, rubble, dredged spoil, and flyash) curves 3 miles into the lake to form an outer harbour. The headland, built roughly along the 30 foot depth contour, deflects littoral drift sands from the east out to deep water. Thus, the drift sand that created and maintained Toronto Islands, now no longer reaches those islands. Since the headland also intercepts much of the easterly wave action, erosion at the islands has not materially increased.

The nearshore zone from Cherry Beach around to the Western Gap is characterized by well sorted uniform sand characteristic of littoral deposits. In deeper water (i.e. in excess of 100 feet where wave generated currents are not strong) finer particle size materials deposit to form a mud bottom.

West of the islands, the dominant feature is Humber Bay. From Ontario Place to the Humber River, the shoreline is protected by an offshore breakwall of concrete capped cribs resting on the firm sand bottom. West of the Humber and extending beyond Mimico Creek, the shoreline is predominantly stoney with bedrock close to the surface. In water depths greater than approximately 30 feet, the bay bottom is characterized by silty muds.

2.2. WATERFRONT USE

The waterfront area described is used for water supply, wastewater disposal, recreational use and commercial shipping. Potential conflicts could arise as development pressures on these uses intensify.

The New Toronto, Toronto Island, R.C. Harris and Scarborough water filtration plants are expanding to an aggregate capacity of 410,000,000 GD. Treated effluent from Ashbridge's Bay sewage treatment plant and Humber sewage treatment plant (combined capacity 242.5 MGD expanding to 290 MGD) is discharged to the lake via submerged outfalls. Storm drains along the waterfront will continue to discharge combined sewage during periods of high runoff in the foreseeable future although sewage flow will decrease as Toronto's separation program proceeds.

The shoreline is currently allocated primarily to recreational users. Sailing, paddling and rowing clubs are located at Balmy Beach, Ashbridge's Bay, the Outer Harbour, Toronto Islands, Ontario Place and west of Exhibition Park. The Eastern Beaches, Cherry Beach, Centre Island Beach, Hanlan's Beach and Sunnyside are used extensively, if not for bathing, for wading and sunning. MTRCA's program of upgrading existing waterfront parks and providing new facilities can be expected to attract many more users to the area.

Although dip netting for smelt is popular in April-May, sport fishing is not extensive along Toronto's Lake Ontario shoreline. The Ministry of Natural Resources is examining the feasibility of establishing a sports fishery.

The Toronto Harbour Commissioners' plan to develop the Outer Harbour as an extension to the Inner Harbour's commercial facilities. At present, most commercial shipping is through the Western Gap, however, the Eastern Gap is being enlarged to serve as the major entrance of the future.

3. SURVEY METHODS AND RESULTS

3.1 SURVEY METHODS

In June 1972, Ponar samples were collected in the Toronto Western Gap and in the approach channel from the Canada Department of Public Works' vessel, "Mimico". Phleger core Samples were attempted but were unsuccessful due to the firm sandy nature of the sediments.

In July, 1972, push-rod core samples were taken at the borrow areas for the Toronto Harbour Commission Pilot Project No. 1 from the THC's vessel "Mallard". The Phleger sampler was again unsuccessful in the firm sand. At this site, direct underwater observations of the dredged sand fill were made on August 1972 by scuba divers from MOE and THC. After the dredging was complete and the sand berm covered over with truck-dumped common earth fill, the site was sampled for sediment quality.

In September and October 1972, the major waterfront sediment sample collection was conducted from Ashbridge's Bay on the east to Mimico Creek in the west. The bulk of the samples were taken in the estimated zone of influence of the proposed main harbour dredging and related Aquatic Park development. Each sample was taken by Shipek sampler from the Ministry's vessel "Monitor IV". The samples were described visually and submitted for chemical analysis. A representative selection was also submitted for mechanical analysis to verify the accuracy of the visual descriptions as to sand, silt, clay. Vessel positioning was by visual estimate at short range and by radar at distance.

A shortcoming of the above sampling programs, was the inability to obtain a sample more than one-half a meter below the sediment surface. To examine the deeper sediments, the THC on October 10, 1972, dug a series of test holes using their derrick No. 50 rigged with a clamshell bucket. Samples of material brought to the surface in the clamshell were submitted for analysis. The fine, firm sand proved to be hard digging and most of the holes could only be excavated to -3 feet. Soundings indicated that the sand ran into the hole with each grab, necessitating a large cone-shaped hole to get a deep sample.

In February 1973, samples were collected from the Keating Channel to determine the suitability of dumping those sediments at an unconfined disposal site. Where possible, the samples were taken through the ice with a push-rod corer. Other stations were sampled by Ponar casts.

In conjunction with the Ashbridge's Bay landfill, MTRCA proposed dredging the bay to improve the draught and to obtain sand for beaches on the landfill. MOE examined the sediment quality in the proposed dredging area on May 9, 1973, taking push-rod cores from a small boat.

Throughout the summer of 1973, staff scuba divers examined work in progress at the East Headland, Aquatic Park, Ashbridge's Bay landfill, Bluffer's landfill, and Mimico landfill. The inspections were made to assess changes in sediment

type attributable to the construction work, note the underwater characteristics of the various materials placed in the lake, and to evaluate the effects of different construction techniques.

3.2 RESULTS

The characteristics of the surface sediments are shown in the following figures. The orientation of the sampling program to the main harbour dredging project is readily apparent. Unfortunately, not all parameters could be analysed at each station due to the laboratory work load. This has resulted in gaps in the data, particularly for the western area of the waterfront.

At Pilot Project 1, the dredging operation did not appear to materially alter the nature of the sandy bottom. Divers found that the coarsest particle sizes were near the dredge discharge at the top of the berm slope, while the finest size sand particles deposited near the toe. After common earth fill was truck dumped on the berm (an unknown quantity of fill was eroded into the water) sampling indicated that organic and heavy metal contents were elevated above background near the fill. The surface sediment near the berm was clay-silt, rather than sand. These findings have been reported previously in the water quality surveys report on Toronto Harbour Commission Pilot Dredging Project 1.

As indicated in Figure 1, the naturally occurring sediments in the nearshore zone from Ashbridge's Bay to Gibraltar Point are uniform sized sands virtually free of organics. At depths exceeding 100 feet, beyond the effect of wave generated currents, finer particles settle out to form an organic clay-silt mud. In the lee of the main headland, a clay-silt deposit also occurs.

Figures 2 and 3 show that the organic content, nutrients, heavy metals and oil and grease are higher in the silts and clays than sandy sediments.

To the west, Humber Bay is characterized by silty sediments, except very close to shore in water depths less than 30 feet where coarse sediments predominate. As expected, the chemical results indicated higher organic and nutrient levels in the silts than the sands.

Levels of all parameters measured were elevated near the Ashbridge's Bay STP outfall, in the Keating Channel, and inside the Eastern Gap.

At the test holes excavated with the THC clam shell, the bulk of the material encountered was fine sand, although isolated thin bands of gravel, stiff clay and organic detritus were noted. A one-half inch to two inch layer of clay silt overlaid the sand at some stations in the lee of the headland. Oil and grease and heavy metals showed a decrease in concentration with increasing depth at each station sampled. Due to the nature of clamshell excavation, it is impossible to accurately state what depth sampled material came from, but where the hole was more than a foot below the original surface, the mean results were as follows: lead - 8.47 ppm; zinc - 18.3 ppm, chrome - 23.9 ppm, cadmium - 0.45 ppm; ether solubles - 148 ppm.

It is interesting to note that a sample taken by the clamshell in the same general area, but in the cut left by the 24 inch cutter suction dredge Shuniah shortly after its passage was a reworked mixture about equal parts sand, silt and clay with chemical properties as follows: lead - 120 ppm, zinc - 79.3 ppm; chrome - 79.5 ppm, cadmium - 1.96 ppm; ether solubles - 836 ppm.

The quality of the Keating Channel sediments varied with the distance from the mouth of the Don River. Relatively clean sands found where the Don emptied into the channel graded to contaminated organic clay ooze down the channel at the Cherry Street bridge.

Sediments in the inner portion of Ashbridge's Bay were a mixture of grossly contaminated sand, silt and clay. In that segment of the bay open to Lake Ontario, clean sand predominated.

Scuba diver investigations of THC Pilot Project II and the main harbour dredging disposal (Aquatic Park) confirmed that Pilot Project I results could be extrapolated to the larger scale project. Under moderate wave action, the dredged sand adopted a similar shape at each location. A nearly flat shelf of gravel and coarse sand developed from shore to about the 6 foot depth. From the 6 foot depth, the berm sloped at approximately 4:1 down to the original lake bottom. The finest sand and silts deposited at the toe of the slope. On the exposed side of the berm, no significant build-up of silts occurred. In sheltered areas, such as the westerly aquatic park basin, silts accumulated to depths exceeding 18 inches.

Diver investigations of the 3 MTRCA landfills underway in 1973, revealed variations caused by the different site locations and types of fill.

The Mimico landfill had been under construction since 1972. By the summer of 1973, trucked earth fill and rubble formed a semi-enclosed basin around the mouth of Mimico Creek. Divers found that a silt-clay ooze had deposited in the basin over the original sand and till bottom. On the outer face of the fill, the silt accumulation was not significant.

The Bluffer's landfill at the base of Scarboro bluffs has also been underway since 1972. The fill material at this site is predominantly silt size and little rubble is available for armouring. By the summer of 1973, the fill was advanced to approximately the 20 foot depth contour, completely intercepting the littoral drift. East of the fill a broad sand beach was accumulating over predominantly glacial till sediment. West of the fill for 2000 feet the area was starved of sand. The basin formed by the landfill contained a deep accumulation of soft clay-silt.

The Ashbridge's Bay landfill was started in June 1973. By July a 1 inch silt layer had formed over the original sand bottom in the lee of the fill. Divers observed that under calm conditions the bottom waters were turbid up to 200 feet from the fill, although surface waters were clear.

4. DISCUSSION OF SURVEY FINDINGS

Surface sediment characteristics in the nearshore zone of the Toronto waterfront have been and are continuing to be altered to varying degrees at construction sites across the waterfront. Areas once characterized by sand bottom now have a covering of clay-silt mud.

The pilot dredging projects demonstrated that little effect resulted from unconfined disposal of sand other than some grain size sorting on the underwater slopes. When common earth fill was added, it formed a mud layer at the toe of slope and accumulated in sheltered areas.

Contaminants occur at markedly higher concentrations in the recent silts and clays than in sands or glacial age clay till. Unfortunately, there is insufficient data to characterize the Humber Bay silts. It is postulated that the heavy metals, oil and grease, and organics are adsorbed onto the fine grain size silt and clay particles. The potential sources of contamination are many but the mechanisms for creation of any given contaminated mud zone have not been proven.

The largest such zone is that in the lee of the Main East Headland. The headland was created by dumping common earth from various excavations throughout the city, demolition rubble, rock, fly ash, and dredge spoils from the Keating Channel and slips in the inner harbour. Wave action on the unprotected headland erodes material suspending fine particles and moving others downslope. Direct observations of barge dumping operations indicate that fine material spreads laterally a considerable distance on contact with the bottom. Further, suspended material carried to the Outer Harbour via the Eastern Gap or the cooling water outfall of the Hearn Generating Station could deposit in the relatively sheltered water behind the headland.

Measurements of the chemical quality of fill delivered to the headland vary widely but elevated concentrations of heavy metals have been recorded. Presumably, this could occur only in surface soils, particularly those near roadways. Fine grain size sediments from the Keating Channel have contaminant levels equalling the greatest measured in the headland deposit. It has been suggested that as they settle clay particles could adsorb organics and heavy metals from the water column. Studies are underway to determine if this is a significant factor on the Toronto Waterfront.

The increased heavy metal concentrations in the reworked sediments which settled into the cut left by the cutter suction dredge may imply that any operation which agitates sediments and separates the fines will concentrate contaminant levels in those fines.

Concentrations of lead, zinc, and oil and grease in the sediments around the Ashbridge's Bay STP outfall point to it as one source for these materials.

Very high levels of contamination in the inner portion of Ashbridge's Bay indicate that the sewers which empty there are a source of gross pollution. Dredgings from the inner bay are thus unsuitable for beach building and require containment on disposal to prevent redistribution of contaminants.

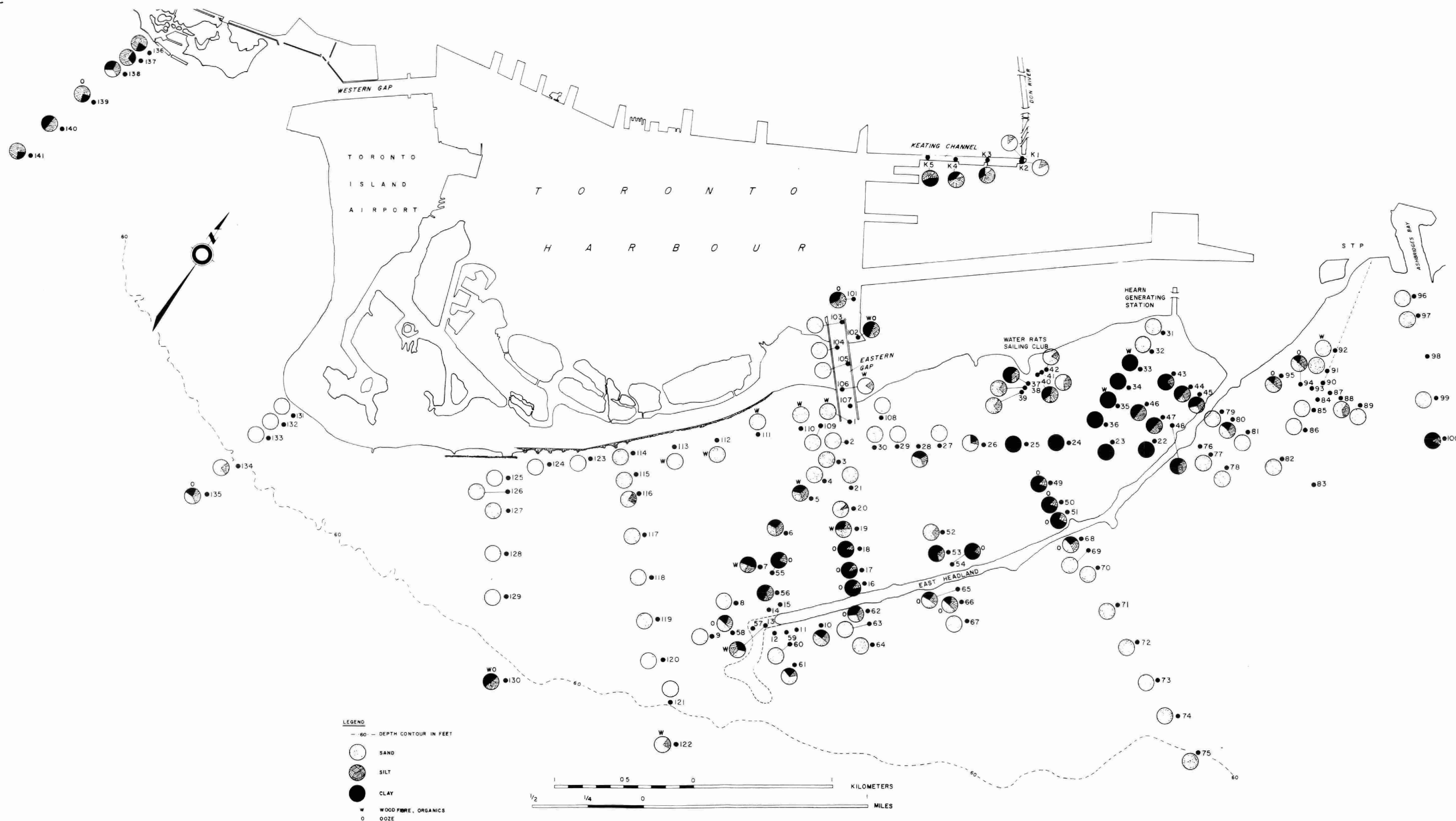
Suspended material from these sources and others could deposit in sheltered areas near shore or be carried out to the deep area of Lake Ontario. The sedimentation effects which occur at the headland are evident to varying degrees at the MTRCA landfills.

The basin created at the Mimico landfill is accumulating mud quickly since it traps material carried down Mimico Creek, in addition to any eroded trucked fill. Maintenance dredging will be necessary to permit continued use of the boat launch ramps. The quality of dredged material may require on-land disposal at considerable expense to the Conservation Authority.

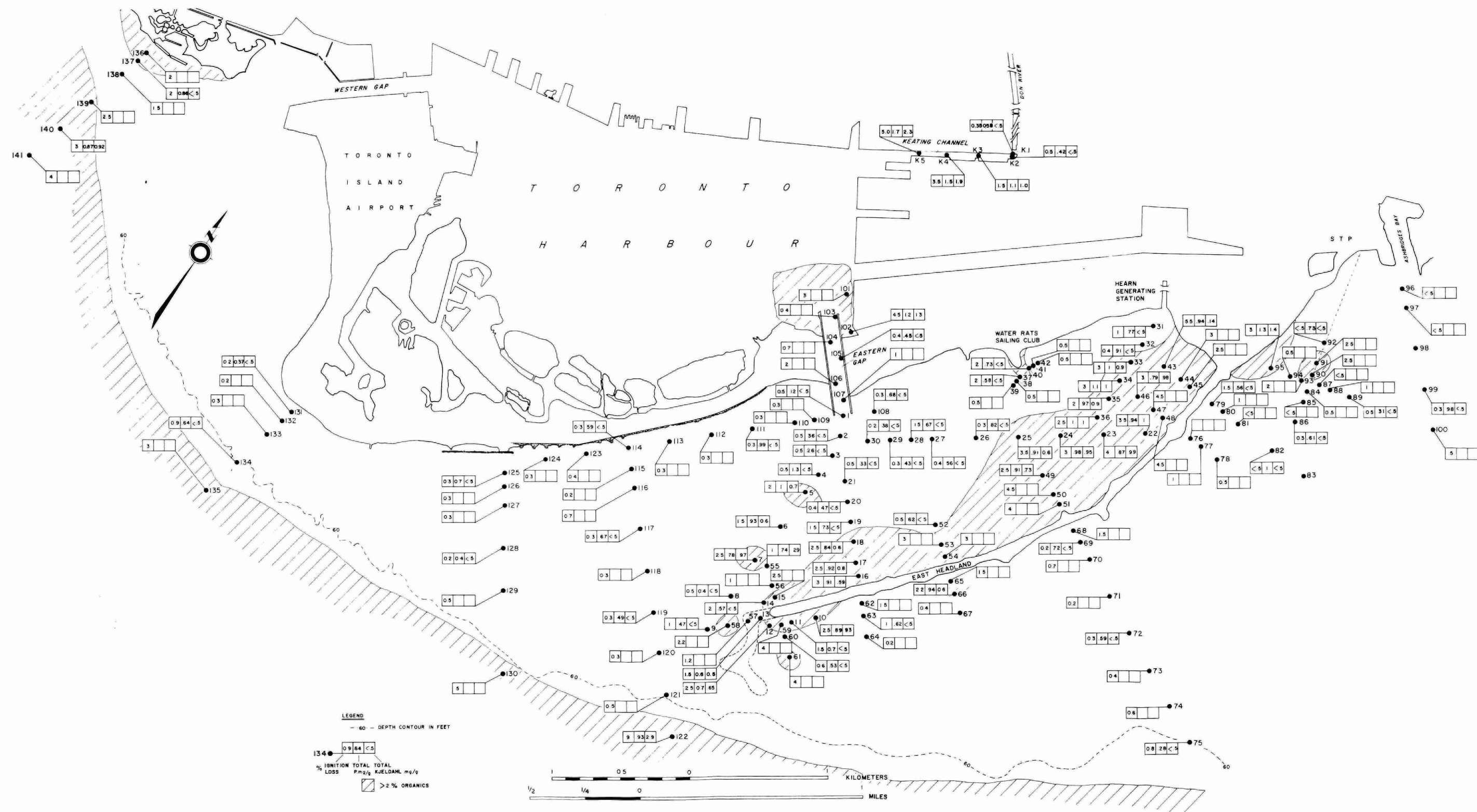
The sheltered area at Bluffers Park accumulates material eroded from the bluff itself in addition to losses from the artificial fill. The very soft mud bottom has rendered the basin unsuitable for the originally proposed bathing beach.

During the survey period, the silts around the Ashbridge's Bay landfill appeared to be solely the result of truck dumping operations.

In summary, all of the landfill sites have caused changes in sediment and water quality which could adversely affect existing or planned water uses.



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FIG. 1 TORONTO CENTRAL WATERFRONT PHYSICAL CHARACTERISTICS OF SURFACE SEDIMENTS	
SCALE: AS SHOWN	
DRAWN BY: C. K. LEE	DATE: MARCH 1974
CHECKED BY: B. W.	DRAWING No: RB 19 74



ENVIRONMENT ONTARIO

FIG. 2
TORONTO CENTRAL WATERFRONT
ORGANIC AND NUTRIENT CONTENTS
IN SURFACE SEDIMENTS

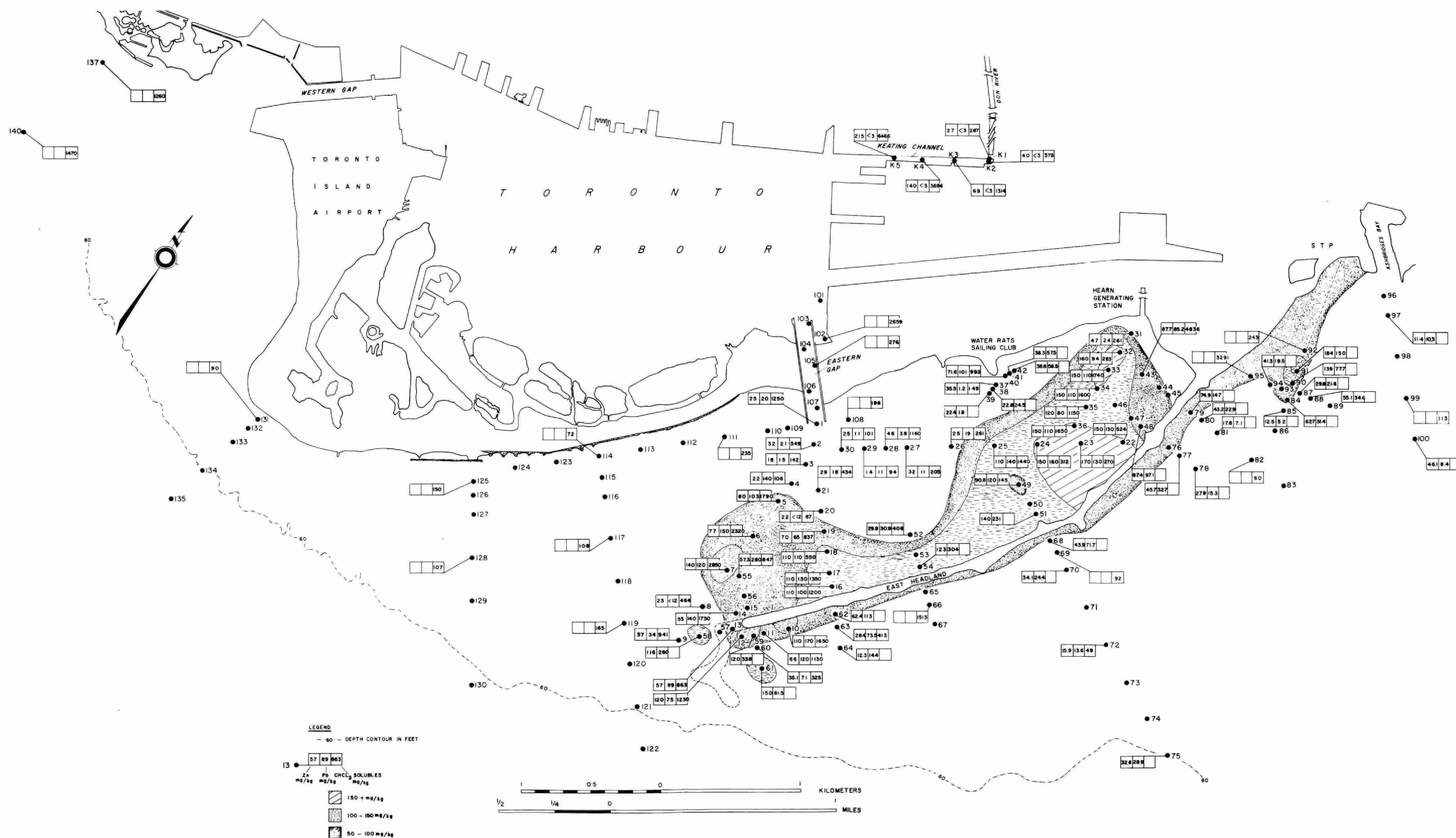
SCALE: AS SHOWN

DRAWN BY: C. K. LEE

DATE: FEB. 1974

CHECKED BY: B. W.

DRAWING No: RB 14 74



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FIG. 3
TORONTO CENTRAL WATERFRONT
ZINC, LEAD AND CHCL₃ SOLUBLES
(ZINC CONTOURED)

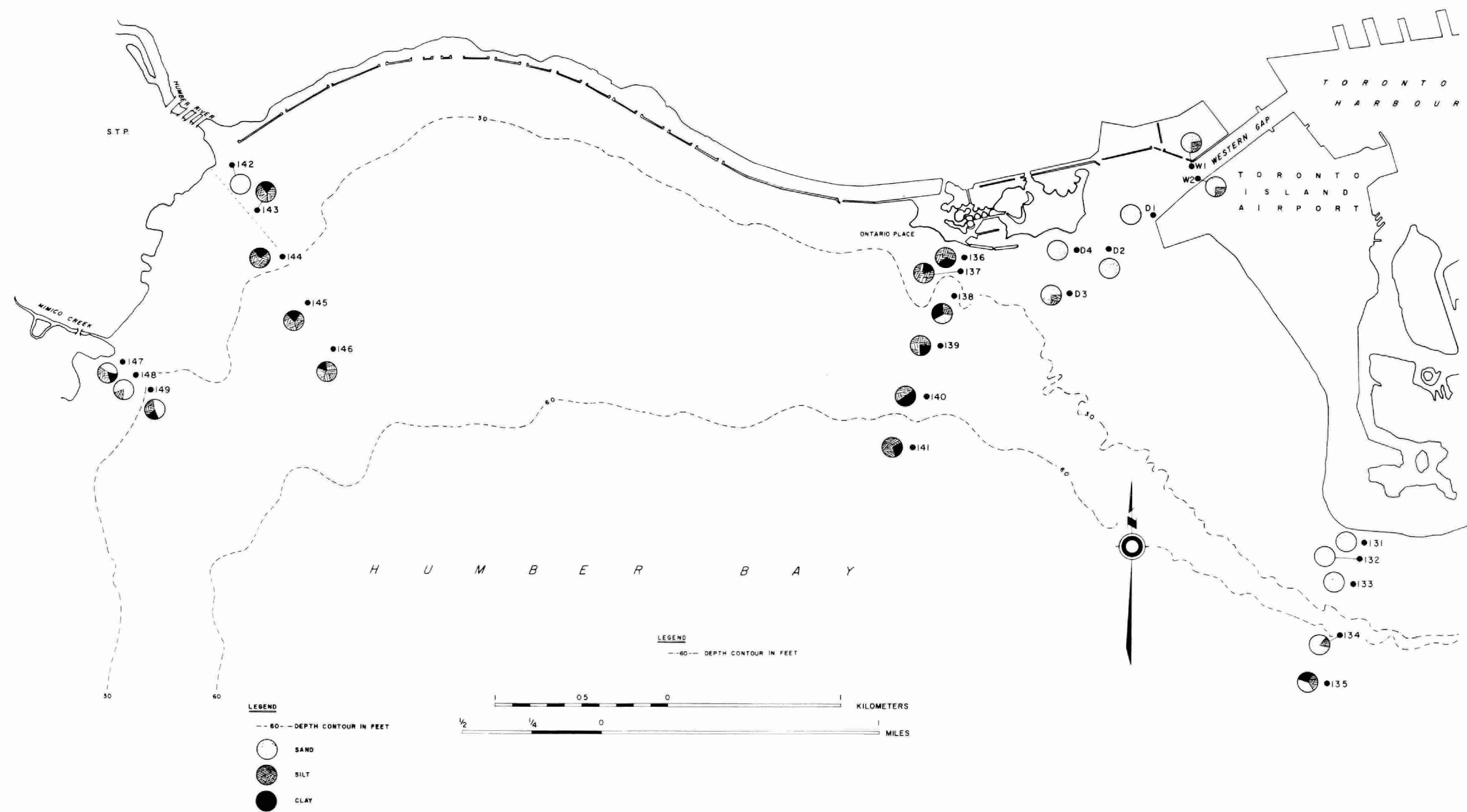
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DATE: FEB. 1974

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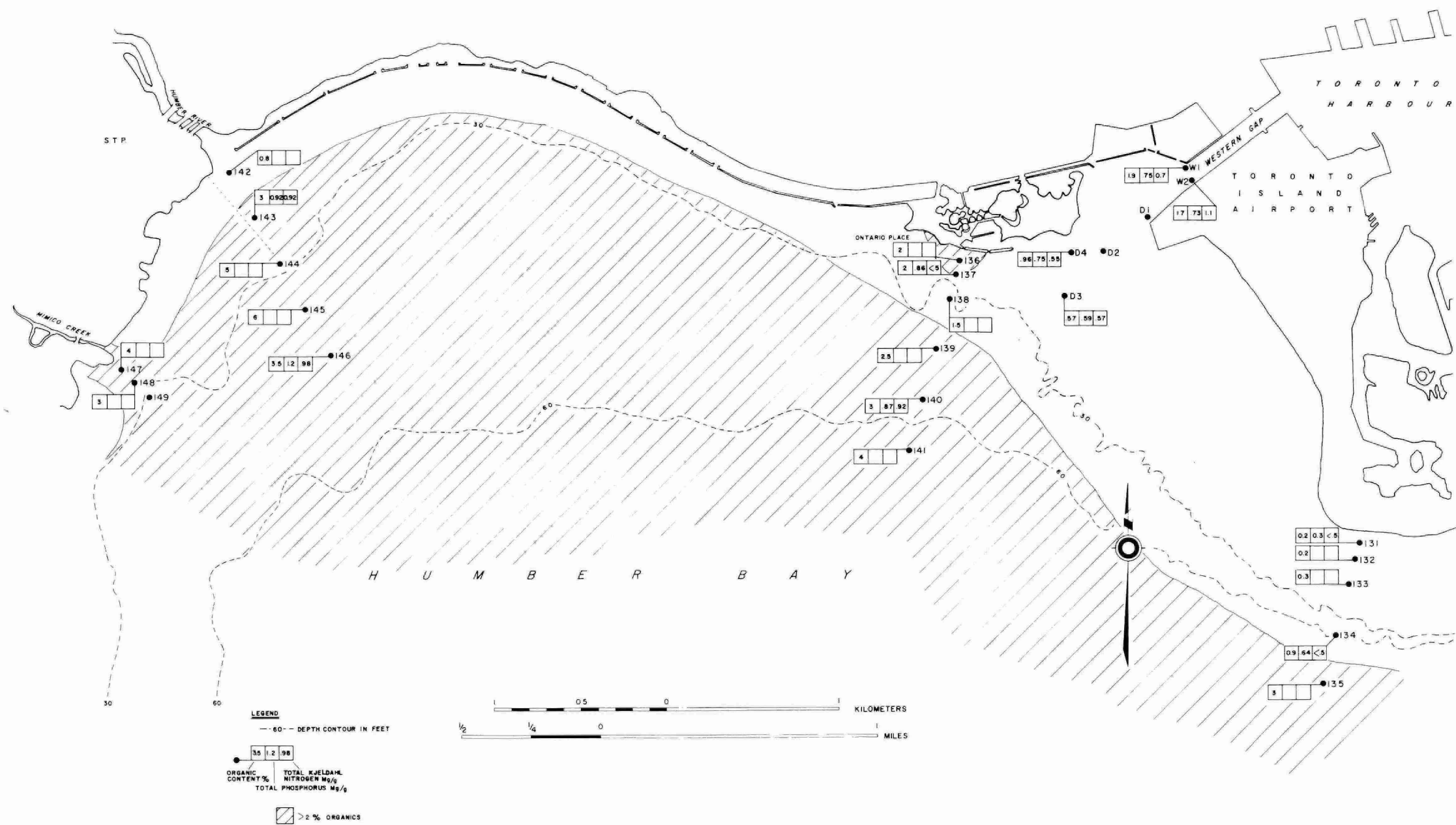
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FIG. 4
 HUMBER BAY
 PHYSICAL CHARACTERISTICS OF
 SURFACE SEDIMENTS

SCALE: AS SHOWN	
DRAWN BY: C.K. LEE	DATE: MARCH 1974
CHECKED BY: B.W.	DRAWING No: RB 18 74



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FIG. 5
HUMBER BAY
ORGANICS AND NUTRIENTS IN
SURFACE SEDIMENTS

SCALE: AS SHOWN

DRAWN BY: C.K. LEE

DATE: FEBRUARY 1974

CHECKED BY: B.W.

DRAWING No: RB 15 74

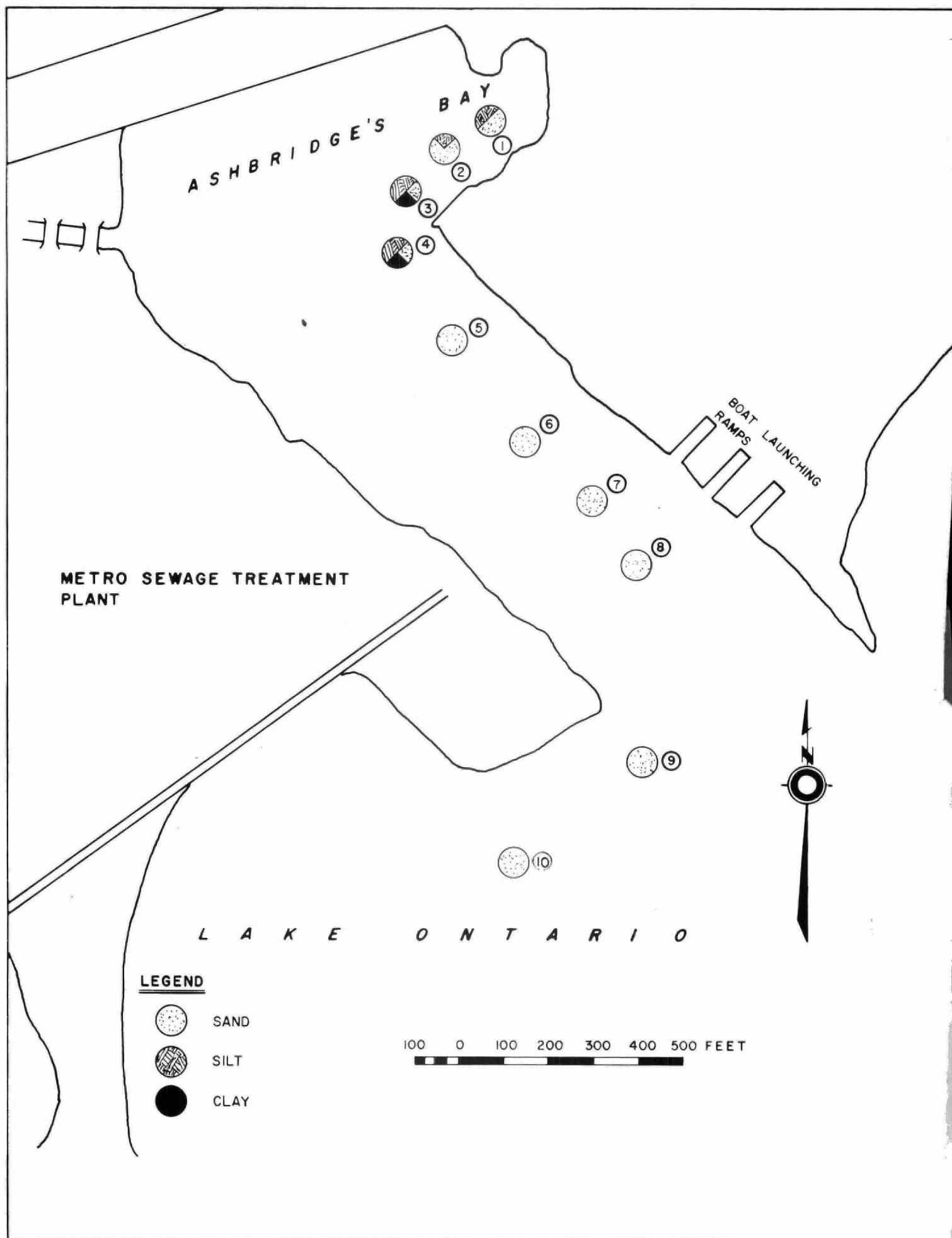


FIG. 6 ASHBRIDGES BAY SURFACE SEDIMENT PHYSICAL CHARACTERISTICS

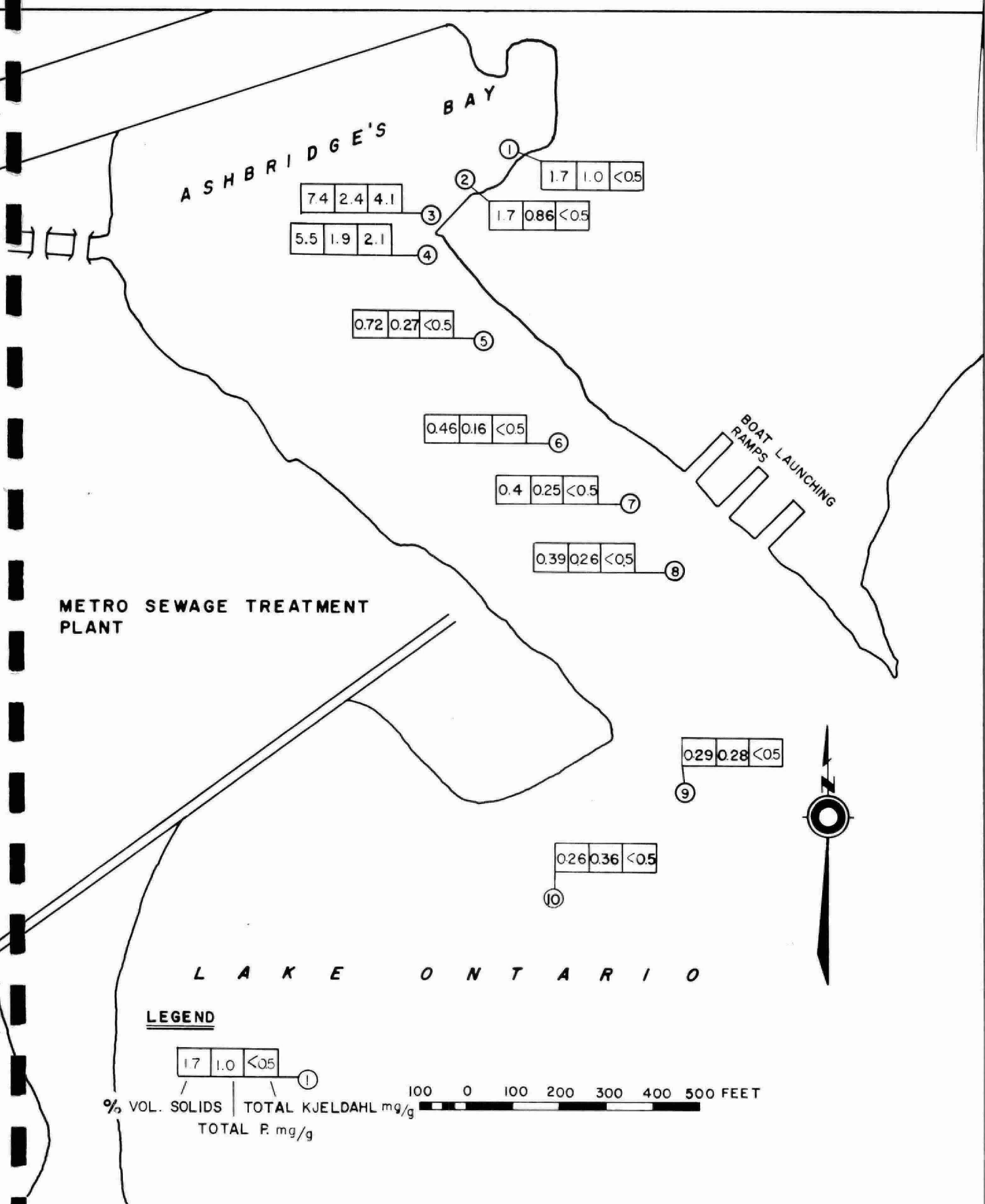


FIG. 7 ASHBRIDGES BAY SURFACE SEDIMENT ORGANIC AND NUTRIENT CONTENTS

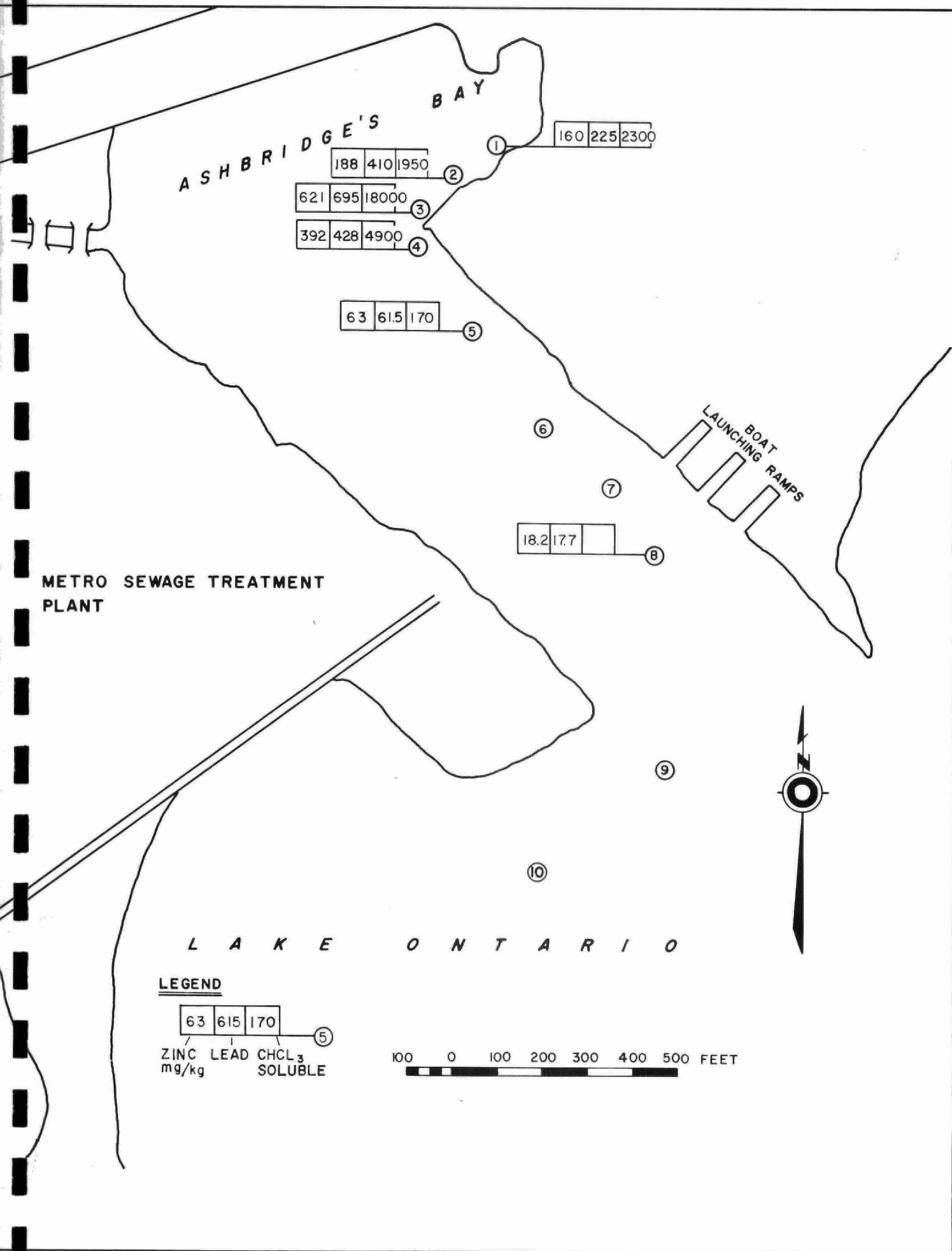
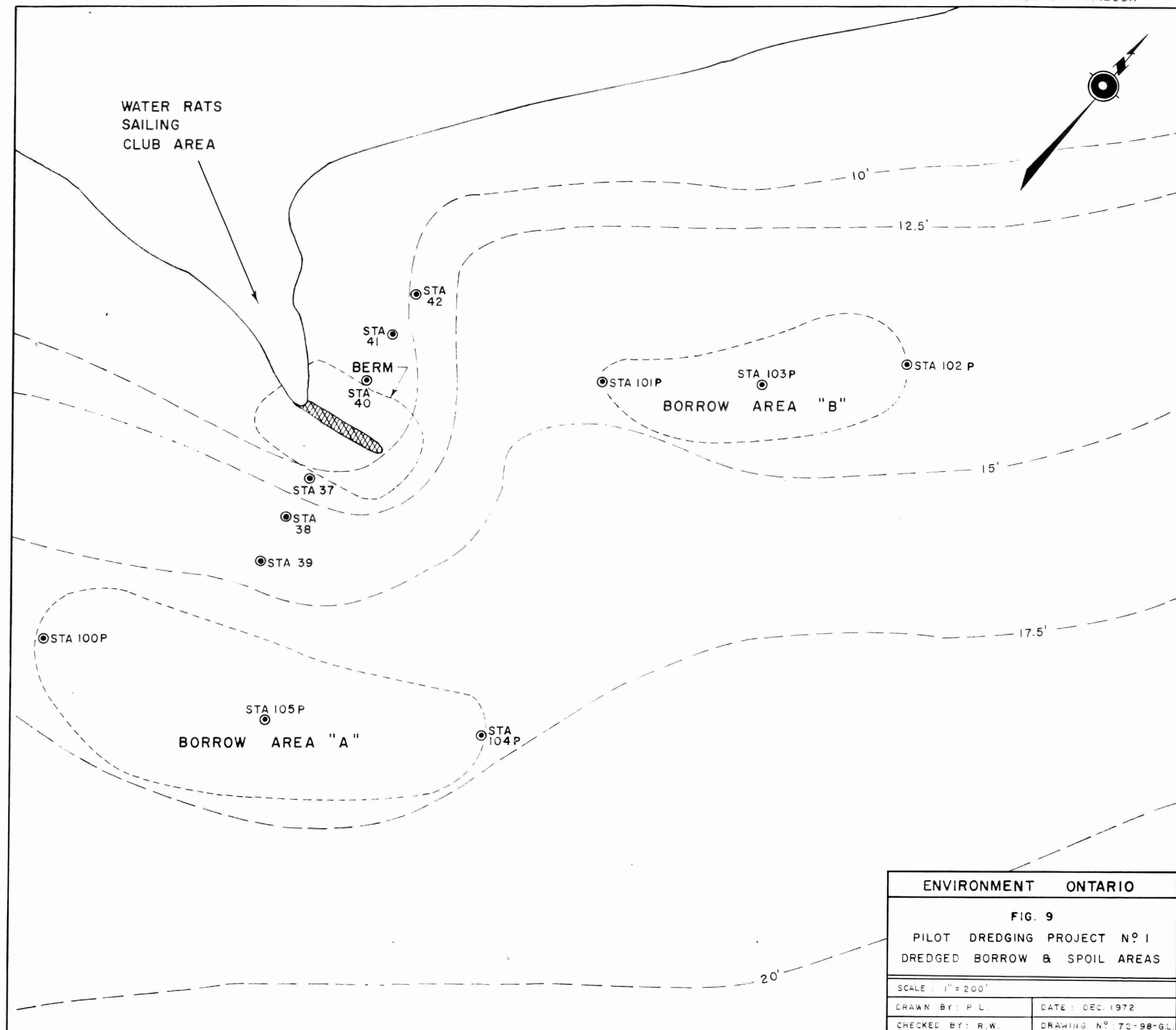


FIG. 8 ASHBRIDGES BAY SURFACE SEDIMENT HEAVY METAL AND CHLOROFORM SOLUBLE LEVELS



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FIG. 9

PILOT DREDGING PROJECT NO. 1
DREDGED BORROW & SPOIL AREAS

SCALE: 1" = 200'

DRAWN BY: P.L.

DATE: DEC. 1972

CHECKED BY: R.W.

DRAWING NO.: 72-98-GL